Frameworks for Sustainable Energy Projects in Developing Countries – Lessons from Indonesian Case Studies

- Background about Indonesia & Renewable Energy in Indonesia
- Renewable Energy acculturation model: The acculturation of the PV-Wind-Diesel hybrid system in the village of Oeledo
- The I3A framework: A diagnostic tool to assess energy service / arrangement sustainability and a design tool to design a sustainable energy service arrangement

Maria Retnanestri
retnanestri@ipenconsulting.com; m.retnanestri@unsw.edu.au
Guest Lecture, Sustainable Energy in Developing Countries, UNSW Sydney 27 August 2012

Dr. Maria Retnanestri

Dr. Maria Retnanestri is a Director of Ipen Pty Ltd, a Lecturer in the Department of Electrical Engineering at STTNAS Jogjakarta College, Indonesia, and a Visiting Fellow in the School of Electrical Engineering and Telecommunications at the University of New South Wales. She holds the degrees of Bachelor of Electrical Engineering (STTNAS Jogjakarta), Master of Engineering Science in Electrical Engineering (UNSW) and PhD in Electrical Engineering (UNSW).

In her PhD research, Dr Retnanestri developed the I3A (Implementation, Accessibility, Availability and Acceptability) Framework to investigate overall sustainability of renewable energy projects, considering their institutional, financial, technological, social and ecological sustainability dimensions. From 2008 to 2011, she then further developed and applied this research to identify ways to overcome barriers to renewable energy for sustainable development in Indonesia with financial support from an Australian Development Research Award. With that financial support, she conducted more than 20 workshops, seminars, public lectures, field visits and study tours in Indonesia involving various kinds of renewable energy stakeholders in knowledge sharing and capacity building activities.

Selected indicators 2010 (WB 2012, IEA 2012, BP 2011)

<table>
<thead>
<tr>
<th>Country</th>
<th>Pop (Millions)</th>
<th>GDP (US$, B)</th>
<th>GDP/capita (US$)</th>
<th>Elc Cons kWh/cap</th>
<th>Elc Ratio (%)</th>
<th>Pop w/o elec (Millions)</th>
<th>CO2 (MT)</th>
<th>CO2 T/capita</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>22</td>
<td>1,235</td>
<td>50,748</td>
<td>11,113</td>
<td>100</td>
<td>-</td>
<td>399</td>
<td>18.57</td>
</tr>
<tr>
<td>China</td>
<td>1,338</td>
<td>5,926</td>
<td>4,428</td>
<td>2,631</td>
<td>99.4</td>
<td>8</td>
<td>7,000</td>
<td>5.31</td>
</tr>
<tr>
<td>India</td>
<td>1,170</td>
<td>1,727</td>
<td>1,410</td>
<td>571</td>
<td>75</td>
<td>290</td>
<td>1,743</td>
<td>1.46</td>
</tr>
<tr>
<td>Indonesia</td>
<td>237</td>
<td>706</td>
<td>2,945</td>
<td>630</td>
<td>64.5</td>
<td>82</td>
<td>406</td>
<td>1.73</td>
</tr>
</tbody>
</table>

RE electricity generation, installed capacity 2010 (BP 2011)

<table>
<thead>
<tr>
<th>Country</th>
<th>Geothermal</th>
<th>Solar PV</th>
<th>Wind</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>1.1 MW</td>
<td>504 MW</td>
<td>2.1 GW</td>
</tr>
<tr>
<td>China</td>
<td>24 MW</td>
<td>893 MW</td>
<td>44.8 GW</td>
</tr>
<tr>
<td>India</td>
<td>189 MW</td>
<td>13 GW</td>
<td></td>
</tr>
<tr>
<td>Indonesia</td>
<td>1.2 GW</td>
<td>25 MW</td>
<td>3 MW</td>
</tr>
<tr>
<td>Total Asia Pacific</td>
<td>4.5 GW</td>
<td>7.4 GW</td>
<td>63 GW</td>
</tr>
<tr>
<td>World</td>
<td>11 GW</td>
<td>40 GW</td>
<td>200 GW</td>
</tr>
</tbody>
</table>
Brief overview of the Indonesian electricity system – 2010

HDI:
Life expectancy, educational attainment, living standard

MPI:
Poor health, education & living standard

Un-electrified in 2009: 84 millions. Lower electrification ratio correlates to high MPI & low HDI

Electricity development plan for up to 2019:
• State Utility PLN: Additional 55 GW by 2019 (Coal 65%, Geothermal 10%, Gas 8%, Cogeneration 6%, Hydro 6%, RE 5%, Diesel 1%). Small scale NRE: 3GW (Micro Hydro 51%, PV 20%, Biomass 13%, Gasified coal 8%, Wind 5%, Biofuel 3%, Ocean 1%)

RE capacity installed 2009 & planned for 2025

<table>
<thead>
<tr>
<th>RE Potential</th>
<th>Technical Potential</th>
<th>Installed 2009</th>
<th>Planned 2025</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geothermal</td>
<td>28 GWe</td>
<td>1.2 GWe(^1)</td>
<td>16 GWe(^1)</td>
</tr>
<tr>
<td>Biomass</td>
<td>50 GWe</td>
<td>500 MWe(^1)</td>
<td>870 MWe(^4)</td>
</tr>
<tr>
<td>Biofuel</td>
<td>650 million $</td>
<td>1 million $</td>
<td>30 million $</td>
</tr>
<tr>
<td>Biogas Digester</td>
<td>Data NA</td>
<td>2012: 8,000 units</td>
<td></td>
</tr>
<tr>
<td>Large Hydro</td>
<td>76 GWe</td>
<td>5.7 GWe(^2)</td>
<td>11 GWe(^2)</td>
</tr>
<tr>
<td>Mini &amp; Micro Hydro</td>
<td>218 MWe(^4)</td>
<td>1.4 GWe(^3)</td>
<td></td>
</tr>
<tr>
<td>PV</td>
<td>4.8 kWh/m²/d, 1.2 GWp</td>
<td>25 MWe(^2)</td>
<td>580 MWe(^2)</td>
</tr>
<tr>
<td>Wind</td>
<td>3-6 m/s, 9 GWe</td>
<td>3 MWe</td>
<td>240 MWe</td>
</tr>
<tr>
<td>Ocean</td>
<td>240 GWe</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

RE techno park, Baron beach, Jogjakarta, 2010

Indonesian electrification ratio, HDI & MPI

Un-electrified in 2009: 84 millions. Lower electrification ratio correlates to high MPI & low HDI

Electricity development plan for up to 2019:
• State Utility PLN: Additional 55 GW by 2019 (Coal 65%, Geothermal 10%, Gas 8%, Cogeneration 6%, Hydro 6%, RE 5%, Diesel 1%). Small scale NRE: 3GW (Micro Hydro 51%, PV 20%, Biomass 13%, Gasified coal 8%, Wind 5%, Biofuel 3%, Ocean 1%)

RE integration in Indonesia

- Grid-connected: Non-intermittent energy resources ie geothermal, hydro and biomass generation; PV with battery storage
- Isolated, off-grid & stand-alone applications: Intermittent energy resources requiring battery storage: Centralized PV, Hybrid PV-Wind, SHS, Wind power, Pico Hydro
- Transportation: Biofuel – mostly exported to Europe, further uptake require more infrastructure
- Cooking: Biogas & Biomass stoves – acculturation effort required


6MW Biomass PP in Bekasi, West Java

The 600 kWp PV Hybrid system installation (with battery storage) in Morotai Island, North Maluku, Indonesia as part of PLN’s* 1000 Islands Electrification Program.

*As an established utility, PLN is in a strong position to provide institutional certainty for long-term operation & facilitating RE acculturation

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**Micro Hydro development in Indonesia**

*As per January 2012 (PLN 2012)*

<table>
<thead>
<tr>
<th></th>
<th>PLN</th>
<th>IPP</th>
<th>kW</th>
</tr>
</thead>
<tbody>
<tr>
<td>In operation</td>
<td>103</td>
<td>17</td>
<td>155,105</td>
</tr>
<tr>
<td>Under Construction</td>
<td>11</td>
<td>35</td>
<td>137,708</td>
</tr>
<tr>
<td>PPA, permit, proposal, FS</td>
<td>83</td>
<td>192</td>
<td>677,368</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>197</strong></td>
<td><strong>160</strong></td>
<td><strong>970,182</strong></td>
</tr>
</tbody>
</table>

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**Oeledo Village, Rote Island, NTT Province – Overview 1**

- Location: A remote coastal village located on Rote Island, at 11S and 123E, the southernmost Indonesian island bordering Australian waters
- Travel to Oeledo from Jakarta: By air to Kupang (NTT’s capital city), Ferry from Kupang to Pantai Baru harbor on Rote, then 2 hour drive to Oeledo

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**The KPDAC Continuum – RE Acculturation Model**

*(Knowledge-Persuasion-Decision-Adoption-Confirmation)*

**The Acculturation of the PV-Wind-Diesel Hybrid System in the Village of Oeledo, NTT Province, Eastern Indonesia**

For detailed discussion on conceptual background, see:
http://primo.library.unsw.edu.au/primo_library/libweb/bin/more.jsp?vid= UNSWorks1598

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A cross-flow MH turbine produced by Heksa Hydro in Bandung (2009)

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[Image links to www.flickr.com/photos/optimalpower/6939652244/ for the 100 kW Micro Hydro installation of Gambung Tea Estate, Mekar Sari Village, Bandung, West Java, 2009]
• Climate & environment: 8 months dry season, annual rainfall < 1000 mm per year; Wind speed 3-6 m/s; Solar irradiation 5-7 kWh/m²/d
  

• Economy: Fishing, agriculture relying on upland rice farming and Lontar (Palmyra) palm trees (all parts of Palmyra tree are used for drink, food, medicine, handicraft and building construction); Income per-capita at project start IDR 62K/month

• Social: Isolated community at project start, skeptical that sunlight and wind could be converted into electricity

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Oeledo Village, Rote Island, NTT Province – Overview 2

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The Oeledo PWD system deployment timeline & updates

• 1996-1997: Feasibility study, project approval, project familiarization
• 1998-1999: Project construction, establishment of PLD (Pengelola Listrik Desa, Village electricity utility), managerial and technical training for PLD officials, establishment of village cooperatives to improve local economy through fishing and handicraft improvement training and product marketing beyond Oeledo
• 2000: Commissioning, handing over & project conclusion
• 2001-2003: Project performance monitoring
  • Per capita income improvement: IDR62K (US$7) per month in 1999 to IDR 380K ($40) in 2003. Business development: 1999 – 1 kiosk, 1 fridge, 1 sewing machine; 2003: 10 kiosks, 6 fridges, 6 sewing machines, 1 telephone café, 2 carpenters, 80 fishermen, ice cubes, pumpkin sweets, electric generator rental (battery charging)
• 2004: ASEAN Energy Awards (Manila)
• 2005: Visitors from 30 countries learned about the PWD system deployment
• 2007: Income per capita improved further to IDR 620K ($65), further expansion hampered by high cost of connection and repair cost for imported equipment (electronic controller)
• 2008: Replacement of batteries
• 2010: PLD still functioning, PWD system integrated into Oeledo’s community life, PLD viewed as a model by local authorities for rural/off-grid electrification, external funding required for capital investment and build local expertise for O&M

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Oeledo PV-Wind-Diesel (PWD) Hybrid System Overview

• An AIJ project between G7 and GOI deployed as a model CDM project: Technology transfer, capacity building & sustainable development, facilitated by E7 & Womintra
• Project cost: US$ 1.8 million for capital investment; Users to pay for use & O&M fees
• Nominal capacity 30kW; Subscribers 127 households (600 people) with 0.5-2 Amp load limits; Electricity tariff IDR800 (US¢9) per kWh

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Building local economy within the Oeledo context: Building financial capacity from pre-existing economy & culture

• Women empowerment program: improving skills & quality control for handicrafts, the production, packaging & marketing of sweets made from pumpkins & other businesses
• Provision of fishing equipment (boat, nets, fish preservation & marketing)
• Establishment of village cooperatives (saving & loan services, product marketing)
**Framework for Financial-Technological Capacity Building**

**Market mapping & strategies to build local capacities**

- **Financial Capacity** (Market segment)
  - Quadrant I: Most Autonomous
    - Full Commercial
  - Quadrant II: Semi Autonomous
    - Semi Commercial Model
  - Quadrant III: Least Autonomous
    - Development Model
  - Quadrant IV: Semi Autonomous
    - Semi Commercial Model

- **Technological Capacity**
  - Less familiar with RET
  - More familiar with RET
  - Less wealthy segment (less commercial)
  - Wealthier segment (more commercial)

- **Capacity building is required to build local autonomy**

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**Per capita GDP & electricity consumption 2007**

*Selected Asian countries (WB 2011) & Oeleedo (Dauselt 2009)*

<table>
<thead>
<tr>
<th>Country</th>
<th>GDP per capita</th>
<th>kWh per capita</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>$2,651</td>
<td>2,429</td>
</tr>
<tr>
<td>India</td>
<td>$1,105</td>
<td>1,153</td>
</tr>
<tr>
<td>Indonesia</td>
<td>$1,059</td>
<td>1,089</td>
</tr>
<tr>
<td>Malaysia</td>
<td>$1,165</td>
<td>1,458</td>
</tr>
<tr>
<td>Philippines</td>
<td>$1,685</td>
<td>1,587</td>
</tr>
<tr>
<td>Singapore</td>
<td>$8,574</td>
<td>8,366</td>
</tr>
<tr>
<td>Thailand</td>
<td>$3,643</td>
<td>2,037</td>
</tr>
<tr>
<td>Oeleedo</td>
<td>$840</td>
<td>60</td>
</tr>
</tbody>
</table>

GDP & kWh per capita of Oeleedo remain low compared to the Indonesian average, however Oeleedo’s per capita income increased tenfold from the installation of the PWD system in 1999 to 2007.

(Australia 2010, GDP per capita $50,748; kWhs per capita 11,113)

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**Renewable Energy Technology (RET) transfer:**

*Holistic view of technology, RET as cultural capital & KPDAC continuum*

- **Holistic view of technology**
  - Interpretation of technology as a compound of **hardware** (equipment), **software** (skill, knowledge) and **orgware** (institution, rules), based on Dobrov (1979, “The Strategy of Organized Technology in the Light of Hard-, Soft, and Org-ware Interaction”, Long Range Planning, Vol 12 August 1979 pp 79-90)

- **RET as cultural capital**
  - Parallel interpretation of technology as objectified, embodied & institutionalized cultural capital, necessary to understand requirements for technology transfer for RET to be integrated into a pre-existing local culture. Cultural capital concept was introduced by Bourdieu (1986 “The Forms of Capital”, in Richardson J, Handbook of Theory and Research for Sociology Education, Westpoint CT: Greenwood pp 241-258)

- **RET acculturation process** expressed using the **KPDAC continuum**
  - To explain the acculturation stages and the process of deploying the RET hardware, software and orgware into the community, highlighting the roles of all stakeholders involved in the process (noting that RET stakeholders act as agents of RET acculturation). The KPDAC continuum was constructed from the work of Rogers (2003, Diffusion of Innovations, Fifth edition, Free Press, New York, ISBN 0-7432-2209-1)”
Holistic View of Technology: **Hardware**, **Software** & **Orgware**

**Hardware - Technical means:** Machines, technical components, computers

**Software - Methods of operating:** Instructions, programming, skills, attitudes

**Orgware - Policy power:** Organizational structure, regulations, management

**Objectified Cultural Capital:** Realization of theories, objectified in media such as writings, monuments, instruments, machines

**Embodied Cultural Capital:** Long-lasting disposition of mind & body requiring process of embodiment for acquisition

**Institutionalized Cultural Capital:** The institutionalization of CC through education & training

Technology as Cultural Capital: **Objectified, Embodied & Institutionalized**

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The **KPDAC Continuum & Acculturation process for RET**

**RET Acculturation:** The extent to which RET diffuses into and is assimilated by a community

**RET Innovation-decision process:** Potential adopters progress from gaining knowledge of RET, to forming an attitude toward RET, to a decision to adopt or reject RET and, if to adopt, to confirm or repudiate the adoption decision (adapted from Rogers 2003)

<table>
<thead>
<tr>
<th>Prior Condition</th>
<th>1 Knowledge</th>
<th>2 Persuasion</th>
<th>3 Decision</th>
<th>4 Adoption</th>
<th>5 Confirmation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unaware of RET</td>
<td>Aware of RET</td>
<td>Form unfavourable attitudes to RET</td>
<td>Decision to adopt or reject RET</td>
<td>Adopt RET, reject may occur</td>
<td>Confirmation of RET adoption</td>
</tr>
</tbody>
</table>

**Roles of Facilitators in each stage of the RET Acculturation process**

- **Diagnose problems, shed light on alternative ways to address problems**
  - Establish information-exchange relationship; Knowledge awareness; Promotion; Education: Provide sufficient and accessible information

**RET Acculturation Process**

- **Implementation, financial & technical assistance, user education**
- **Stabilize adoption, discourage discontinuation.**

Hardware, software & orgware must continue to function for RET to become community cultural capital

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**The KPDAC context of Oeledo**

<table>
<thead>
<tr>
<th>Prior Condition</th>
<th>1 Knowledge</th>
<th>2 Persuasion</th>
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</thead>
<tbody>
<tr>
<td>Diagnose problems, shed light on alternatives</td>
<td>Establish information-exchange relationship; Knowledge awareness, Promotion; Education: Provide sufficient and accessible information</td>
<td></td>
<td></td>
<td>Stabilize adoption, discourage discontinuation.</td>
<td></td>
</tr>
<tr>
<td>Isolated community, unaware of RET existence, skeptical of RET feasibility, suspicious of foreign people &amp; ideas, rely on conventional energy</td>
<td>The heart of RET acculturation process in which RET hard-soft-orgware are rolled in into the community as cultural capital</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Field officers stayed for 2 years for the HSO-wares deployment (with high emphasis on orgware) to provide SHS demonstration, form PLD utility, provide technical &amp; managerial training, form cooperatives to enhance local economy, assist in opening up bank accounts, provide handicraft &amp; fishing improvement training</td>
<td>127 out of 354 families decided to subscribe, paid Down Payment &amp; monthly fees</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Communities involved in the decision-making process, implementation, Operation &amp; Maintenance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**KPDAC facilitator’s tasks:** Assist Oeledo villagers to progress from gaining knowledge of the PWD system, to forming an attitude toward PWD system (is it better than previous energy practices?), to a decision to adopt RET and, if to adopt, to confirm the adoption decision.
The Cultural Capital context of Oeledo

- E7: Initial holder of the PWD system CC; Oeledo villagers: Appropriator of the PWD CC
- PWD system hardware (objectified CC) can be transferred in its materiality
- PWD system software (embodied CC – information, knowledge & skill to operate & maintain the PWD system hardware as well as the managerial skill to run PLD utility) must be transferred through an embodiment process, requiring time & effort (labour of assimilation) in which the appropriator must invest personally/first hand; Taking local capability into account helped assimilate the new knowledge into local culture more easily “management tools were adapted to incorporate the PWD system orgware institutionalized the PWD system CC by replication – transferring PWD system software (embodied CC – information, knowledge & skill to operate & maintain the PWD system hardware (objectified CC) can be transferred in its materiality

PWD system orgware institutionalized the PWD system CC by replication – transferring PWD system software by education & training → Providers & Facilitators need to have sufficient resources & capacity for proper technology transfer

Generalization 1 – Building Financial Capacity

The level of effort (financial intervention) & time required to achieve the intended state relative to RET market segment

Generalization 2 – Building Technological Capacity

The earlier the position of target communities in the KPDAC continuum, the greater the effort & time required to facilitate RET acculturation

Generalization 3 – Building RET Financial & Technological Capacities

- Financial accessibility (y-axis): RET to be affordable & profitable (RET still faces challenges to bringing down cost)
- Technological feasibility (x-axis): RET to acculturate in community’s life (RET still faces challenges for wider community acceptance & acculturation)
- The aim is to achieve Q1 situation: RET to be financially & technologically accessible, and
- To assess what stakeholders need to do to bring RET from Research stage to Market stage

The level of effort & time (length of intervention) required to facilitate RET acculturation within the KPDAC continuum context

Levels of effort & time

Q0. Is this the best option?
Q1. What is RET? How does it work? Why does it work?
Q2. What are the advantages in my situation?
Q3. What are the consequences of my decision?
Q4. Where can I obtain RET? How can RET best fit my situation?
Q5. Continue or discontinue RET adoption?

The earlier the position of target communities in the KPDAC continuum, the greater the effort & time required to facilitate RET acculturation
Role of stakeholders in facilitating RET transfer

<table>
<thead>
<tr>
<th>Prior Condition</th>
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<th>5 Confirmation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unaware of RET existence</td>
<td>Aware of RET existence</td>
<td>Form unfavourable opinion</td>
<td>Decision to adopt or reject RET</td>
<td>Adopt RET; Re-invention may occur</td>
<td>Confirmation of RET adoption</td>
</tr>
</tbody>
</table>

**RET stakeholders & roles**

<table>
<thead>
<tr>
<th>Target Communities</th>
<th>Research bodies, universities</th>
<th>Government, Donors, NGO</th>
<th>Industry, Utility, Cooperatives</th>
<th>New adopters/Users – Individual, group</th>
<th>Confirming Users – Individual, group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Needs/Problems</td>
<td>RET Research (Basic &amp; Applied)</td>
<td>RET Demonstration</td>
<td>RET Commercialization</td>
<td>RET Adoption &amp; Diffusion</td>
<td>RET Outcomes</td>
</tr>
<tr>
<td>Prior experience, expectations for energy services</td>
<td>Research, education, hardware, software, orgware expertise</td>
<td>Policy, funding, program, management expertise</td>
<td>Business, hardware, software expertise</td>
<td>Initial outcomes from RET adoption: actual experience</td>
<td>Long-term outcomes from RET adoption: actual experience</td>
</tr>
</tbody>
</table>

Sharing of experience & knowledge among stakeholders to build capacity and design facilitating policy/strategy to achieve successful RET acculturation

The KPDAC continuum, RE study tour & capacity building activities

- Australian Development Research Award (ADRA) research activities (2008-2011): Seminars, workshops, study tours & field visits
- RE study tour provided hands-on knowledge of RE practices → Knowledge is the entry point of KPDAC acculturation → Model for RE capacity building through educational institutions

The I3A framework:

**A diagnostic tool to assess energy service / arrangement sustainability and a design tool to design a sustainable energy service arrangement**


**What is I3A?**

An Implementation that maintains RE service Accessibility (financing, skill, network, resources), Availability (reliability & security of supply) & Acceptability (social & ecological) considering the hardware, software & orgware aspects of RE service delivery during & beyond initial project life

A framework that is used as a diagnostic tool to assess energy service/arrangement sustainability or a design tool to design a sustainable energy service arrangement (scope: can be for country level or technology specific level)

**What are the I3A objectives?**

- Sustainable Implementation: Acknowledge all Stakeholders Interests
- RE Accessibility: Minimize Inequity
- RE Availability: Assure Continuity
- RE Acceptability: Utilize & Enhance Community Resources

Process of implementing a RE project

- Benchmarks/key measures to assess whether a RE project builds & sustains RE Accessibility, Availability & Acceptability

Leave community with enhanced capacity and resources for social innovation
The 21 steps of the I3A model to assess energy arrangement sustainability

I3A Energy Sustainability

Implementation that maintains energy Accessibility, Availability & Acceptability in short & long runs

Implementation
Orgware & Enabling Factors
1. Orgware: Stakeholders, objectives, roles, interrelationships
2. Enabling factors: Policy, strategy, administration, coordination, governance
3. External factors: Other programs, socio-economic, political, global situations

Accessibility
Access to Financing & Resources
4. Affordability–Profitability (A–P) levels
5. Financial intervention to bridge the A–P gap
6. Access to energy financing, market, network
7. Access to energy education
8. Access to energy resources

Availability
Service Reliability & Resource Security
9. Primary resource availability
10. Technical quality: Standards, Safety & Warranties for components, system, installation, appliances
11. Energy system integration
12. Domestic manufacturing
13. After-sales infrastructure
14. Local capable agent
15. User education
16. Utilization of local resources: Norms, institution, economy, local innovation
17. Attributes & Users requirements: Advantage, complexity, compatibility, reinvention, etc
18. Socioeconomic outcomes: Millennium Development Goals (MDG), socioeconomic improvement
19. RE suitability to local physical environment
20. RE waste handling
21. RE contribution to climate change mitigation effort

Acceptability
Social & Ecological Sustainability
16. Utilization of local resources: Norms, institution, economy, local innovation
17. RE attributes & Users requirements: Advantage, complexity, compatibility, reinvention, etc
18. Socioeconomic outcomes: Millennium Development Goals (MDG), socioeconomic improvement
19. RE suitability to local physical environment
20. RE waste handling
21. RE contribution to climate change mitigation effort

I3A covers the Institutional, Financial, Technological, Social and Ecological aspects of RE service delivery

Enhancing the sustainability of RE service delivery in 21 steps using I3A

Implementation: Process of implementing a RE project

Orgware & Enabling Factors
1. Orgware: RE stakeholders, objectives, roles, interrelationships
2. Enabling factors: Policy, regulations, administration, governance
3. External factors: Other programs, socio-economic/political situations

The Oeledo Orgware:

Provider interests/goals:
Governance responsibility, business goals, social goals, credibility, emission reduction (ER) target, public image

User interests/goals:
Energy service/energy benefits, resolve problems related to their energy needs

Common interests/goals:
RE rural electrification

Accessibility: Minimize inequity

Access to Financing & Resources
4. Affordability – Profitability (A–P) levels
5. Financial intervention to bridge the Affordability – Profitability gap
6. Access to RE financing, market, network
7. Access to RE education and training for non RE specialist
8. Access to RE resources

Combined program of RE delivery & empowerment of pre-existing rural economy in NTT improved Users economic standing & helped Users to pay PV service & installments regularly
Generalization 1 – Building Financial Capacity

The level of effort (financial intervention) & time required to achieve the intended state relative to RET market segment

Availability: Assure continuity – Issues

Malfunctioned PV system in Eastern Indonesia and Thailand

PV system, Newcastle NSW, installed 1997
Acceptability: Utilize & enhance community resources

Social & Ecological Sustainability


KPDAC Continuum

Prior Condition
Knowledge
Pression
Decision
Adoption
Confirmation

T1 & T2 Availability and Acceptability domains

T1 Conditional
Acceptance Stage
Users decide to adopt RE

T2 Confirmed
Acceptance Stage
RE Acculturation: Users confirm RE benefits & able to continue to innovate in a socially beneficial manner

Point prone to discontinuation

Hardware, software & orgware must continue to function for RET to become community cultural capital

Acceptability: Utilize & enhance community resources - Issues

Malfunctioned micro-hydro and wind-power systems in Eastern Indonesia

Acceptability: Acculturated RE

Experience with the I3A:
The I3A workshop in Kupang, NTT Province, Eastern Indonesia, 8/6/2010

- Assessment of RE progress and challenges in NTT Province
- Group of mix of different stakeholders discuss, analyze & report the discussion outcomes
  - ABCG stakeholders: Academics, Business, Community and Government
- Demonstrated the use of I3A as a systematic diagnostic tool to identify RE potential and barriers
- Actively engaging diverse stakeholders, I3A can facilitate formation of consensus in identifying issues & formulating recommendations
- I3A qualitative outcomes can be complemented with quantitative enquiries

A traditional 5 kW Micro Hydro installation in the Tundagan village, Central Java, built by a local farmer (Bachri 2000).

Group discussion followed up with report of discussion outcomes
Discuss/analyze the I3A aspects of the two case studies:

1) Have the projects been implemented in a way that maintains energy service accessibility, availability and acceptability considering the hardware, software & orgware aspects of RE service delivery during & beyond initial project life?

2) Have the projects left community with enhanced capacity and resources for social innovation?

### Outcomes of the NTT’s I3A Workshop

**Implementation: Orgware & enabling factors**

1. RE stakeholders: Form Forum Energi Dorah & deliver roles, coordination & interrelationships among RE stakeholders (ABCG Academics, Business, Community and, Government in NTT)
2. Enabling factors: Relevant policy & strategies for mainstreaming RE in NTT, accessible information for all
3. External factors: Complimentary factors: Existing programs and strong commitments from outside NTT to assist RE development in NTT; Competing factors: People in remote NTT are not open to external ideas for change

**Accessibility: Access to Financing & Resources**

4. Affordability – Profitability level: Poverty level in NTT is high (24% in 2010), the A-P gap is significantly high
5. Financial intervention: Financing from state or regional budget, community fund, incentives for RE developers
6. Access to RE financing, market, network: Collaborate with NGO, donor institutions
7. Access to RE education: Community training centre, provision of RE training equipments, field laboratory, technology transfer
8. Access to energy resource: Land dispute may impede RE development

**Availability: Service Reliability & Resource Security**

9. Primary resource availability: Solar resource available across NTT, wind and hydro in certain areas; resource mapping required
10. RE Standards, Safety, Warranties: Use of appliances complying to accepted standards; Training on Standardisation & Certification
11. RE system integration: Experts & training are needed
12. Domestic manufacturing: Maximize local content, transfer of manufacturing capacities to NTT; use of local innovation
13. After-sales service infrastructure: Empower community & cooperatives to sell spare parts & provide after sales service
14. Local capable agent: Design curriculum for RE education from primary school to university level; workshop at kabupaten level
15. User education: Trained community group (through TOT) to train RE users; life skill training eg. RE for agriculture

**Acceptability: Social & Ecological Sustainability**

16. Utilization of local resources: Need understanding on the natural and institutional resources capacities for appropriate project design
17. RE attributes & Users requirements: RE equipments made more affordable, RE beyond lighting, more user friendly
18. Socioeconomic outcomes: RE to create jobs & welfare in NTT; RE for agricultural development important for NTT
19. RE suitability to local physical environment: Need understanding on the impacts of the environmental conditions to RE equipment
20. RE waste handling: Need understanding on the impacts of RE waste to the environment, AMDAL assessment needed
21. RE & GHG mitigation effort: ()

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### I3A exercise:
The Tundagan & the Cinta Mekar micro-hydro case studies

**Acculturated RE:** A traditional 5 kW Micro Hydro installation in the Tundagan village, Central Java, built by a local farmer (Bachri 2000).

The 120 kW Cinta Mekar Village MH, West Java: Accommodation of local requirements: A written agreement was made to allocate at least 300 l/s to irrigate 50 hectares of fields prior to water being used for electricity generation.

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### Conclusion Remarks

**RE development in Indonesia**

- RE share is set to increase in the Indonesian energy mix, however issues related to technological, institutional and socio-cultural integration need to be addressed by a holistic-interdisciplinary approach to maintain RE sustainability

**The KPDAC Continuum, RE Acculturation, Lessons from Oeledo**

- The KPDAC continuum can be used to explain the RE acculturation process and the role of RE stakeholders in that process, in which each stakeholder acts an RE acculturation agent
- The deployment of the PV-Wind-Diesel hybrid system provided an example of the diffusion & acculturation of investment & expertise into a remote community culture
- RE stakeholders (as acculturation agents) need sufficient resources & capacities to facilitate RE technology acculturation (integration of RE technology into communities’ institution and culture) that can be generalized into RE integration at wider level
- RE study tour provided college staff students with access to hands-on knowledge of RE practices, instrumental for creating capable agent for RE acculturation. This can be viewed as a model for RE capacity building through educational institutions

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### Concluding Remarks – Continued

- The 13A framework & NTT Workshop
  - The 13A Framework can be used both as an assessment tool & design tool to design a sustainable energy service arrangement. The scope can be for country level or technology specific level
  - The 13A workshop undertaken in NTT was part of ADRA’s capacity building activities to transfer practical know-how to wider audience. It is used as a systematic diagnostic tool to identify RE potential & barriers and facilitate consensus building among diverse stakeholders in formulating recommendation for further action
- It can be used for assessing/designing a sustainable renewable RE service by applying the following criteria:
  - Sustainable Implementation: Create facilitating environment
  - Accessibility: Facilitate access to financing, skills, network
  - Availability: Ensure availability both during & beyond project life
  - Acceptability: Facilitate RE acculturation into local life by utilization & enhancement of pre-existing resources
- The 13A process provided qualitative outcomes that can be broken down further or complemented with quantitative enquiries